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Preamble

This paper reports on the development and activities of the molybdenum disulfide lubrication industry in Soviet Bloc countries.

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INTRODUCTION

Soviet Scientific Information Hardly Accessible

While the Soviets seem to have no difficulty at all to secure research and scientific information from Western countries, their own information is nearly inaccessible and hard-to-get.

As a result of a special investigation by Soviet security agencies, the Academy of Sciences of the USSR in Moscow has been reprimanded for disclosing scientific information in its periodicals:
"The Presidium of the Academy of Sciences did not take proper measures for the registration of scientific research work.

The scientific establishments of the Academy of Sciences, contrary to existing laws on registration of scientific work, have directed material on completed scientific research, due for registration, directly to the All-Union Institute of Scientific and Technical Information for publication, and published the material, prior to registration for clearance, in the periodicals of the Academy of Sciences.

These shortcomings are the responsibilities of the various departments of the Academy of Sciences."

This proves that Soviet scientists, even if they would want to cooperate, are not free to exchange relatively new information with western countries. The following is quoted from Soviet security regulations:

SOVIET LAW ON INVENTIONS AND PATENTS

(Handling of Secret Inventions and Discoveries)

"Inventions and discoveries which concern the defense of the state are classified SECRET.

The Committee on Inventions and Discoveries (Patent Office, USSR), Council of Ministers, USSR, can classify them secret if this is considered to be in the best interest of the state.

Publication of material of any invention or discovery which is classified secret or dissemination of their essence by any means is an unlawful act subject to criminal prosecution. When an author believes that his suggestion may have a secret nature, he is obligated to take all necessary precautions against improper dissemination and is required to hand over the suggestions to the interested state organ of the USSR.

To develop secret inventions or discoveries, the interested enterprise is required to furnish special quarters for the authors to prevent them from working on their inventions at home.

Declarations on secret inventions, with the exception of TOP SECRET inventions of defense significance, are accepted through the secret organs.

Declarations on top secret inventions pertaining to new methods of armament and combat techniques and their tactical use are accepted and examined by the Ministry of Defense, USSR."

Western Literature Easily Accessible to Soviets

Scientific information from Western countries is easy to get for the Soviet All-Union Institute of Scientific and Technical Information. This can easily be demonstrated by the following quotation from a report published in Communist East Germany:

> "After production through purification had been announced in American literature references and after products with excellent lubricity had been offered in the (West German) Federal Republic, under the designation "MOLYKOTE", the Research Department of the Institute of Organic Chemistry, under the direction of Professor Dierichs, Freiburg Mining Academy, decided that the time had come to examine this new lubricant more thoroughly." (1)

In the United States of America, the Soviet Union secures much industrial information through its official trading establishment, AMTORG, in New York.

One report indicates that lubricants, made by a British manufacturer (Rocol), were tested in East Germany.

031 EAST GERMANY

a. Basic Research Activities

All basic research work for the development of molybdenum disulfide lubricants in East Germany is done by a mining academy, the

BERGAKADEMIE
Freiberg, Sachsen, DDR

under the supervision of Dipl. Ing. H. Schetelich.

b. Mining Operations

The rawmaterial, molybdenite, is processed by the

WISMUTH A.G. (Sachsen),

an enterprise jointly operated by the Soviet Union and East Germany for the exploitation of the Uranium pitchblende deposits near the Czecho-Slovakian border. Molybdenite is a by-product.

Four mines are presently in operation, yielding molybdenite for commercial exploitation:

1.	PERCHTELSGRUN	Annual MoS_2 output: 5000 kg
2.	ALTENBURG (Vogtland)	---
3.	RODEWISCH	---
4.	JOHANNGEORGENSTADT	18 of the shafts were closed in December, 1958, when pitchblende deposits had been exhausted; this resulted in a reduction of MoS_2 production (by-product).

Other deposits are located at JEUCHENTHAL-HALLE, BLEIBERG, ANNABERG, BERGISCHUBDA, SCHNEEBERG.
A purity of 94% is obtained by flotation and a purity of 98 to 99% is obtained by chemical processing.

c. Manufacturing Facilities

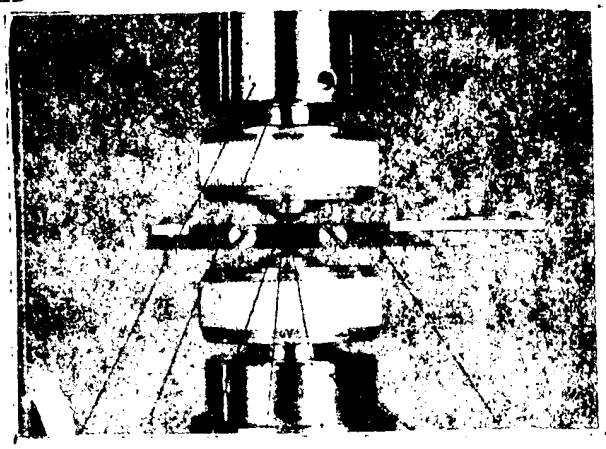
The manufacturing of molybdenum disulfide lubricants is done by the

V.E.B. ELEKTROCHEMISCHES KOMBINAT
Bitterfeld, DDR,

a nationalized combine. They make 8 products (?), including a methanol suspension and lubricating sticks, sold as "Molbit" lubricants.

d. Laboratory Testing

A new testing machine, the FISCHER Two-Ball Tester, has recently been developed and manufactured in Dresden.
It is used for the testing of lubricants containing molybdenum disulfide and other solids.



e. Field Testing by Consumer Industries

In addition to exchanging application data, several industrial (03) users are field testing new products. Several of these industrial customers are:

ZEISS-IKON Camera Works, Dresden
LEUNA, Chemical Plant, Merseburg
V.E.B., Steel Mill, Riesa.

087	ROUMANIA	
	BAITZA (47N/23E)	Deposits in Bihor Mountains, 0.4% MoS_2
088	BULGARIA	
	ZAGORA (42N/25E)	Mo deposits (04)
	LOZEN (41N/24E)	Mo deposits
089	CZECHO-SLOVAKIA	

At least one patent (5) has been issued in the CSR, describing the processing of MoS_2 for lubrication purposes. According to one report, the CSR exhibited molybdenum disulfide lubricant in collapsible tubes during 1957 Industrial Fair in Vienna.
Mo deposits are located: ZINNWALD (ERZGEBIRGE)
SCHLAGGENWALD (BOHEMIA)
RUSKITZA.

090 POLAND

Mo deposits are located at:

TATRA (50N/20E) - Mountains,	Mo deposits (06)
WOLYNIA	Mo deposits
JASNOGORKA	Mo deposits (07)
SARNI	Mo deposits
LOMNITZ (Silesia)	
HIRSHBERG (")	
EHRENFRIEDERSDORF (Silesia)	

Tests with MoS_2 were also made at the Physical Institute at KRACOW Inst. of Technology (08).

091 U.S.S.R.

(a) Research

All experimental and reseearch work is done by the Academy of Sciences in Moscow (Prof. Deryaguin).

The great interest of the Soviet lubrication industry in the research results of Western countries is also reflected by the following report.

"FRICTION and WEAR of Machinery," (09) published by the Institute of Mechanical Engineering, Leningrad, indicates that the following papers have been translated into Russian:

1. SONNTAG. A.: Molybdenum Disulfide Simplifies Extreme Pressure Lubrication Problems.
2. SONNTAG, A.: Schmiereigenschaften und industrielle Anwendungen von reinem Molybdaendisulfid.
3. SPENGLER. G.: Molybdaendisulfid, ein neuartiges Schmiermittel.
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5. BRUNNER-PEDRINI: Pruefung von Schmiermitteln auf ihre Schmierfaehigkeit mit dem Wieland - und Vierkugelapparat.
6. HUGEL, M.G.: Essais de lubrification avec des complexes du molybdene solubles dans les huiles.
7. HUGEL, G.: Fragen der Schmieroelforschung.
8. MOLYKOTE: Internationaler Kongress ueber die Anwendung von Molybdaendisulfid als Schmiermittel.
9. TSCHANTER, E. Erfahrungen mit Molybdaendisulfid als Schmiermittel.

(b) Rawmaterials

The U.S.S.R. has the world's largest molybdenum ore reserves (including low-grade disseminated ores) and world's second largest molybdenum reserve. (10)

The following is a partial list of principal deposits:

01. R.S.F.S.R.

a. CHIKOY (50N/108E) - Molybdenite (11) in quartz veins and massive molybdenite veins. (3 to 4% Mo)

b. KAROBI (43N/44E) - Molybdenite-quartz veins in dacite of Caucasus; Mo content is 0.08%; Mo reserve of 5,000 metric tons.

c. KRASNOYARSK (56N/93E) - Several molybdenite deposits in district

d. NIZHNIY TAGIL (58N/59E) - More than 70 deposits in entire range of Ural mountains, also tungstide deposits.

e. UMAL-TA (52N/133E) - - Steeply dipping veins (12) with 0.6 to 2.4% Mo content. (Bureya River)

f. CHITA (52N/114E) - MoS_2 deposits

02. UKRAINIAN SSR

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03. BYELORUSSIAN SSR

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04. AZERBAIDZHAN SSR

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05. GEORGIAN SSR

a. TYRNY-AUZ (43N/43E) - Complex ore (13) in metamorphosed (14) steeply dipping deposit; 0.2 to 0.3% Mo and Tungsten (Caucasus.)

06. ARMENIAN SSR

a. AGARAK (39N/46E) - Porphyry copper deposit with 0.6% copper and 0.04 to 0.1% Mo; reserve of 15,000 metric tons of molybdenum.

b. PIROUDAN (39N/46E) - Copper molybdenum ore (15) containing 1.0% Cu and 1.0% Mo; reserve of 14,000 metric tons.

c. KAJARAN (40N/45E) - Zangezur Mountains; MoS_2

07. UZBEK SSR

a. AIMATYK (41N/70E) - Porphyry-copper deposit with Mo and 1.1% Cu; reserve of 900 metric tons.

08. TURKMEN SSR

09. TADZHIK SSR

PAMIR (37N/72E) - Mountains; molybdenite

10. KIRGHIZ SSR

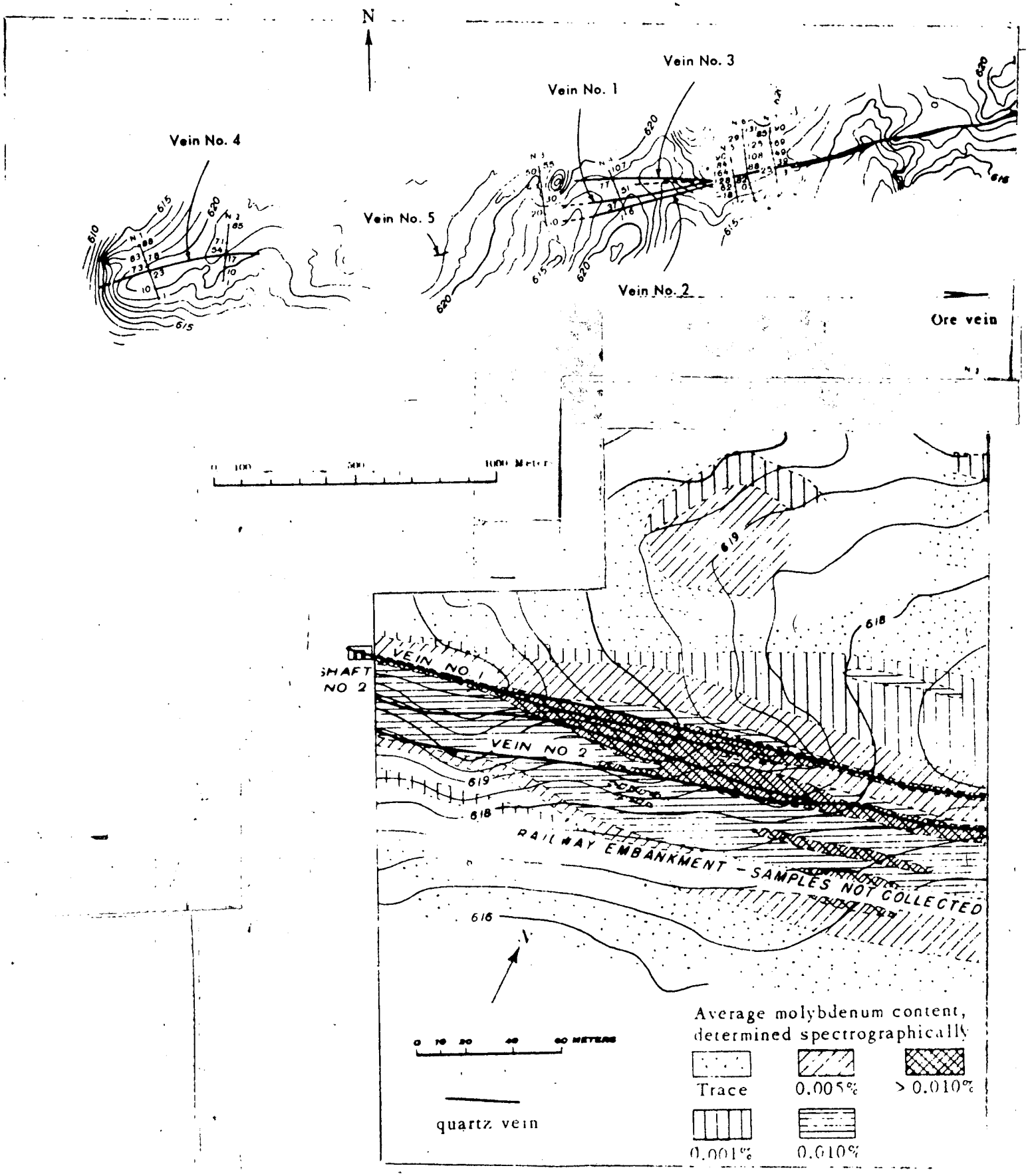
ALATAU (42N/75E) 0.1% to 2.5% MoS_2; 0.5% is average

11. KAZAKHSTAN SSR

a. BOSHCHE-KUL (52N/74E) - Porphyry copper; 0.6% Cu and 0.6% Mo; reserve of 7,000 metric tons.

b. CHINDAGATUI (50N/85E) - Pyritic ore with molybdanite and wolframite.

3. EAST KOUKRAD (40N/74E): Molybdenite mined for Mo; reserve of more than 5,000 metric tons of molybdenum.



d. KOUNRAD (47N/75E): Porphyry-copper; (16) 1.0% Cu (17) and 0.008 (recoverable) Mo; reserve (17) of 16,000 metric tons of molybdenum (18).

e. KALGUTA (49N/87E): Molybdenum and tungsten deposits.

f. BALKASH (75N/77E): Molybdenum smelter (19), (20)

g. TURKESTAN (43N/68E): Mo deposits

12. KARELO-FINSKAYA SSR

a. TACHTARNUMPTSHORSKER (67N/32E) Mo deposits on Kola peninsula

13. MOLDAVIAN SSR

14. LITHUANIAN SSR

15. LATVIAN SSR

16. ESTONIAN SSR

Numerous other molybdenite deposits (21), (22) in the Soviet Union are known.

(c) Manufacturing

In April 1958, the Academy of Sciences (23) reported on "Experiences in Applying Molybdenum Disulfide" in lubrication.

The Moscow Steel Institute (24), also in 1958, reported on applications in COLD ROLLING OF PIPE. A coating of MoS_2 applied to the mandrel surface, combined with the use of a conventional lubricant, lowers the coefficient of friction, reduces the pressure of the rolled metal on the roll by ten-twenty percent, and reduces the build-up of rolled metal on the mandrel surface, so that the mandrel life is increased two-three times. The surface quality of the rolled pipe is greatly improved. Since MoS_2 is especially effective at higher pressure between rolls and metal, its greatest use is in the rolling of very thin walled pipe and in deep drawing.
Another report, published in 1958, indicates that tests with molybdenum disulfide in plastics were run on a Four-Ball Machine (25).

The Soviets have also reported on the successful uses of synthetic molybdenum disulfide (26), in 1959. Molybdenum gas flame coatings were used as a protection against erosion and wear. "With the aid of hydrogen sulfide, the molybdenum coating may be changed into a sulfur-molybdenum coating; this exhibits good lubricating properties at high loads and is thermally stable to 400° C."

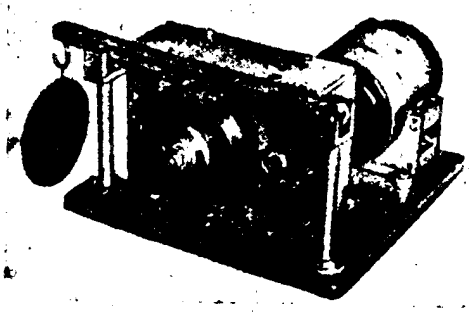
One report from Helsinki (Finland) indicates that MOLYKOTE Lubricants are used by a meat packing plant for the lubrication of their Russian-made MOSKOVICH cars. This proves that the Soviet automobile industry has knowledge of the uses of MoS_2 lubricants in the automotive field.

Another interesting paper (27) reports of tests, made in 1960, with molybdenum disulfide as a filler for lubricants used in deep drawing.

(d) Laboratory Testing Machines

The Academy of Sciences in Moscow has developed several lubricant testing machines:

1. SABELNIKOV Contact Area Friction Force Tester
2. LAZAREV -DERYAGUIN Wire Tribometer
3. KRUSHCHEV Testing Machine
4. KRAGHELSKY Buxcom Tester
5. MASLOV Wear Tester →



092 YUGOSLAVIA

Mo deposits are located at:

SURDULICA (43N/22E)	- Mo deposits (EPP)
RHODOPE (42N/23E)	- Macedonian Mountains 0.1% to 1.0% Mo
MEZICA (Miess-Igerz)	- Mo deposits (28)
MACKATIKA	- Mo deposits

093 ALBANIA

Exports small amounts of ferro-molybdenum to Soviet Union

094 HUNGARY

The use of Molybdenum disulfide lubricants is generally known in Hungary. The Hungarian Petroleum Research Institute in Budapest reported of tests with MoS_2 to determine wear rates on pistons of internal combustion engines. (29)

Mo deposits are located at MOLDAWA
RUSKBERG
REZBANYA
SZASKA

110 - COMMUNIST CHINA

China has extensive molybdenum ore deposits.

NORTH CHINA

MANCHURIA

(1) YOKAZYOSI - Molybdenum deposits of 0.5% have been reported (30) to exist in the Yokazyosi area.

(2) LIAOTUNG Peninsula (Kwantung) - In 1958, the Russians (31) reported on Chinese molybdenum deposits: "Molybdenum ores occur generally with copper, lead-zinc, and particularly often with wolfram (tungsten). Explored reserves of molybdenum (over 4 million tons) place China second to the U.S. in world reserve".

(3) YANG-CHIA-TZU Mines - These mines, in the Chin-Hsi District, started as a lead-zinc (32) producer in 1935, under Japanese control. It was gradually converted into a molybdenum mine, about 1939. Reserves were then estimated at 8,000,000 metric tons of 0.4% molybdenite ore, of which one half was inferred. During World War II, about 400,000 metric tons of 0.4% molybdenite ore (and several hundred tons of lead zinc tailing) was processed with small quantities of 1.2% ore from another deposit at Ma-Lu-Kou. This yielded about 3,300 tons of 75% molybdenite concentrates. Daily capacity of mine and mill was 900 tons of ore.

(4) MA-LU-KOU - This mine in the Pen-Hai District reportedly carries 1.2% molybdenum ore.

INNER MONGOLIA (Chinese Automomous Territory)

TSIN-LING Mountains (Chin-Ling) - Rich molybdenum deposits were also reported in the Tsin-Ling Mountains, (33), with the world's largest molybdenum mines.

SHANSI PROVINCE

PEIPING MOLYBDENUM SMELTER - A chemical plant in Peiping reportedly started molybdenum metal production in 1958. A purity of 92 to 94% MoS_2 concentrates was expected from non-mixed ores (presumably from YANG-CHIA-CHANG-TZU) and 70% from mixed ores (presumably from South China). Output was estimated at 2,000 tons (some of which was exported to the USSR, East Germany, and Poland).

SINKIANG - Molybdenum deposits were also reported to exist in this province province (44N/88E), which is rich in tungsten, copper, and uranium ores.

i. CHING-HO Molybdenum Mines
ii. AI-MEN Molybdenum Mines
iii. ALA-JILGA DEPOSIT (Dzhilga) - Tolbu River Basin/To-Yun River
A molybdenum deposit is located 4 kilometers west of the Chak-Mak area. The prevailing direction is N50/70E.
iv. BOZ-BELES I DEPOSIT - This deposit is located on the left center slope of the BOZ-BEL-River Valley, near the SULUTEREK MASSIF. The ore body is enclosed in thick gneiss, stretching in a NE 40° direction and dipping 70° to the SW. They consist of a group of layered quartz veins carrying specks of molybdenite. The sulfide-bearing veins are 0.5 to 2 meters wide and up to 20 meters long. The distribution of molybdenite within these veins is not uniform. In some sections, it forms commercial concentrations.

CHANTUNG - Molybdenum deposits in this area have been reported.

CHIKLY - Reportedly has molybdenum deposits.

OTHER PARTS OF CHINA

A partial list of molybdenum deposits is shown below:

CENTRAL	YANGTSE River Valley (28N/103E)		Mo deposits
SOUTH	HUNAN Province (28N/112E)		Mo deposits
	JUNGTAI (26N/117E)		Mo deposits
	KWANTUNG (23N/112E)		Mo deposits
	KWANGSI (23N/107E)		Mo deposits
	PING-JANG		Tungstide
WEST	TIBETAN Territory (37N/87E)		Mo deposits
EAST	LIAONING Province (43N/123 E)	3%	Mo deposits
	CHEKIANG (30N/120E)		Mo deposits
	FUKIEN (25N/120E)		Mo deposits

China exports molybdenum concentrates to the Soviet Union. (34)
China claims to have the largest Mo ore reserves of the world. (35)

114 NORTH KOREA

A deposit of Mo is located near TAEYON (40N/126E) (36)
A British firm, CENTORES, Ltd, 14124 Finsbury St., London E.C.2, England, imports molybdenum concentrate from North Korea, according to a dispatch (1958) by the Chinese News Agency.

114A MONGOLIA

Presumably has molybdenum and tungsten ore deposits.

070 CUBA

Cuba has tungsten deposits but depends on imports of MoS_2 from other Soviet bloc countries. Since Cuba's metallurgical industries (37) are receiving foreign aid, molybdenum concentrates will possibly be imported from other Soviet bloc countries. MoS_2 lubricants (glyssolybden) are available in Cuba through at least one outlet:

Albert Eppinger (BASF, Germany)
Zulueta 617, Bajos.

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